Flight to net zero: How sustainable aviation fuel helps achieve carbon neutrality

Swire Pacific Limited

(March 2021)

Executive Summary

Climate change is one of the most pressing challenges facing our planet and its people. President Xi Jinping declared that China will achieve carbon neutrality by 2060. Responding to climate change is a systemic issue that requires vigorous, rapid, and coordinated action, as well as joint efforts by policymakers and corporate citizens. Established in 1816, the Swire Group is a highly diversified global conglomerate. Swire's five business divisions include Property, Aviation, Beverages & Food Chain, Marine Services and Trading & Industrial. As a firm supporter and longstanding practitioner of sustainable development, Swire has a clear group strategy and action plans under its 'SwireTHRIVE' programme to address significant, material sustainability challenges including climate change and decarbonisation, as well as water conservation and waste reduction.

Swire has been in China for 155 years with our businesses centered in Hong Kong SAR (HKSAR) and the Chinese mainland. Swire has always been committed to supporting the Chinese mainland's high-quality development. As Premier Li Keqiang laid out in the *2021 Government Work Report,* an action plan will be drawn up to tackle carbon emissions which we fully endorse. Swire hopes to contribute to, and provide a reference for, the formulation of relevant action plans through our business experience and research. Our studies show that the development of sustainable aviation fuel (SAF) is of utmost significance to the aviation industry's carbon emissions reduction and for China to realise carbon neutrality by 2060. This paper draws on international references, and Cathay Pacific Airways' own experiences to explain the unique challenges of decarbonising air transport and puts forward recommendations for limiting carbon emissions associated with the development of the aviation industry.

As one of the world's leading airlines, Cathay Pacific has implemented various initiatives to mitigate its impact on climate change over the past few decades. This includes continuous improvement of fuel efficiency, the use of carbon offsetting and pioneering the use of SAF. In 2020, Cathay Pacific took a step further with a pledge to achieve net zero carbon emissions by 2050. As existing technologies to improve fuel efficiency reach their limit, and market based mechanisms such as carbon offsetting and trading offer only limited potential in the short to medium term, further operational and infrastructure improvements and new, more radical approaches to aircraft design will be required. Importantly, if the industry's emissions reduction target is to be met, this will also require the widespread adoption and application of SAF.

China is expected to become the world's largest civil aviation market. From being a significant player to the leading player, China’s strategic path in sustainable development is therefore of vital importance to the future of global aviation industry. As a leader in manufacturing and logistics, China’s air transport network plays a vital role in facilitating the flow of goods, direct investment and people. In line with the future trajectory of the country’s aviation activities, China must find an effective solution to reduce carbon emissions stemming from the industry in order to demonstrate its determination to combat climate change.

In addition, the global SAF market is estimated to have an annual potential value of more than RMB640 billion, providing an opportunity for China to harness the value of this market and assume an industry-leading position. Given that the use of SAF is an inevitable trend, China should be forward-looking in terms of formulating supportive policies, cultivating domestic production capacity, improving supply chain development, securing a long term and sustainable supply of SAF and diverging from its dependence on fossil fuels for aviation. Adoption of SAF will also enable airlines to better manage financial risks such as fluctuations in crude oil prices and potential costs from carbon levies. In addition, SAF can contribute to the circular economy and stimulate employment growth in different regions with its wide variety of feedstock, ranging from municipal solid waste, agricultural waste and used cooking oil, to plants farmed on barren land.

At present, the global production of SAF is still in its infancy and accounts for well below 1% of total aviation fuel demand. China has already mastered key technologies in the production and application of SAF and successfully conducted a test flight using SAF as early as 2011. However, its use of SAF is currently limited to testing and one-off flights. Currently there is no public commitment to any long-term production or use of SAF. The policy environment has a significant impact on the development, supply, and application of SAF. Due to the high production cost of SAF at present, policy assistance is key in narrowing the price gap to allow SAF to compete with fossil fuels until scale of production and cost-reduction is achieved. Different policies concerning SAF formulated by different countries result in differing adoption rates. The Chinese government can develop incentives, on both the supply and demand sides, to form a virtuous circle. The government can also draw lessons from international experience with the formation of SAF coalitions around major aviation hubs. China can look for a pilot airport in the Guangdong-Hong Kong-Macao Greater Bay Area to encourage flights departing from the airport to utilise SAF continuously, build a full supply chain of SAF and promote the pilot experience across the whole country, as part of an ambition to become the world’s leader in the development, supply and use of SAF.

Main Paper

Climate change is one of the most pressing global issues. The Paris Agreement aims to limit global warming to well below 2 (and preferably 1.5) degrees Celsius compared to pre-industrial levels. President Xi Jinping announced that China will strive to peak its carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060, demonstrating the Chinese government's responsibility as a major power on this issue. Tackling climate change is a systemic issue that requires vigorous, rapid and coordinated action, as well as joint efforts by policymakers and corporate citizens.

The Swire Group is a highly diversified global business conglomerate established in 1816. Its five divisions include Property, Aviation, Beverages & Food Chain, Marine Services and Trading & Industrial. Having operated in China for 155 years with our businesses centered in Hong Kong SAR (HKSAR) and the Chinese mainland, Swire is fully committed to supporting China's overall development. As a firm supporter and longstanding practitioner of sustainable development, Swire has a clear group strategy and action plans under its 'SwireTHRIVE' programme to address significant, material sustainability challenges including climate change and decarbonisation, as well as water conservation and waste reduction. For example, Swire Properties and Swire Coca-Cola have set science-based carbon reduction targets that have been officially validated by the Science Based Target Initiative (SBTi). These targets not only include ambitious emissions reductions for our direct operations, but a commitment to engage with our suppliers and customers to drive decarbonisation across the value chain. Both companies have also committed to the Business Ambition for 1.5 °C [i], to show our support for the transition to a net-zero carbon economy as a precursor to the international climate conference (COP26) taking place in November 2021.

The Group's Aviation division accounts for over 90% of its total carbon emissions. As one of the world's leading airlines, Cathay Pacific has undertaken various initiatives to mitigate its impact on climate change over the past few decades, including continually improving fuel efficiency, offering carbon offsets to passengers and pioneering SAF. In 2020, Cathay Pacific further committed to achieving net-zero carbon emissions by 2050. The realisation of this target will be largely dependent on the development and application of SAF.

This paper explains the unique challenges faced by the aviation industry in reducing carbon emissions and the significant role offered by SAF in decarbonising the sector and helping China achieve its carbon neutrality goal. It draws on international experience to make recommendations for future development. Premier Li Keqiang said in the *2021 Government Work Report* that an action plan will be formulated to reach a peak in carbon emissions by 2030. We believe that SAF is an indispensable part of the action required to achieve this peak, and hope that our experience and research can be used as a reference for the formulation of relevant action plans. We welcome the opportunity to provide our thoughts in this regard.

I. Unique challenges faced by the aviation industry in carbon reduction

Although aviation only accounts for 2% of all human-made carbon dioxide (CO2) emissions, it still attracts significant concern and controversy. As aviation increases to meet growing demand, the industry faces unique challenges in achieving its ambition to decarbonise and play its full role in tackling climate change.

1. The inevitable trend of aviation industry development

Since the 1950s, the global aviation industry has grown significantly, with passengers carried growing a few hundred times over. [ii] With technological progress and economic development, more and more people are able to enjoy the convenience of air travel, whether for studying abroad, visiting relatives and friends or experiencing different places and cultures first hand. In the past, only the wealthy could afford to fly. Today, many more people can enjoy the benefits brought about by affordable air travel. With continuous economic development, aviation will continue to grow.

In addition, air transport is also an irreplaceable mode of transport. High-speed rail is an effective solution to replace certain short-haul flights, especially for China which has a large high-speed rail network. However, about 80% of the carbon emissions from global aviation come from long-haul flights of over 1,500 kilometres. Many long-haul flights involve crossing oceans and continents. So far, there is no alternative mode of transport to meet this demand.

Given that the aviation industry makes important contributions to economic and social development on a long-term basis, its development should not be curtailed by the fight against climate change. But it must grow in a sustainable way to ensure that it can cope with the challenges brought by climate change and benefit future generations.

2. Limitations of existing technologies

Since the dawn of the modern jet age, the aviation industry has substantially improved its fuel efficiency. Since the 1950s, technological advances in internal combustion engine and overall aircraft design have reduced fuel consumption per seat by more than 80%. At present, the improvement of existing technologies has reached a plateau. While there is still room for improvement, incremental improvements will not be sufficient to counter the pace of growth.

The aviation industry has conducted a great deal of exploration in alternative sources of energy, such as electric and hydrogen-powered aircraft. Last year, Airbus unveiled its plan to develop a hydrogen-powered aircraft for commercial operations in 2035. This game-changing technology, whilst exciting news, still has many limitations. Initial designs have limited range, which are insufficient to meet the needs of intercontinental flights, and only carry half the number of passengers as traditional wide-body aircraft, making them commercially disadvantaged. Aircraft usually have a lifespan of at least 30 to 40 years, so unless commercially-viable, low-carbon aircraft can be adopted at scale from 2030, there is not enough time to rely on this approach to achieve China’s carbon-neutral target by 2060.

3. The limited effects of carbon offsetting and emissions trading schemes

Carbon offsetting or emissions trading schemes are being used in many parts of the world as a tool to curb the growth of carbon emissions in the aviation industry. Since 2012, the European Union has included the aviation industry in its emissions trading system (EU ETS), covering all flights within the European Union. The Carbon Offsetting and Emissions Reduction Scheme of International Aviation (CORSIA) is a global scheme formulated by the International Civil Aviation Organisation (ICAO) to limit net carbon dioxide emissions from international aviation in order to achieve the target of carbon-neutral growth from 2020 [iii].

While these schemes can be used as a temporary measure to offset emissions, they do not directly reduce emissions from aviation. As the demand for flights increases, actual carbon emissions will increase accordingly. As a result, it is expected that the share of man-made CO2 emissions from the global aviation industry will increase from 2% to 3% by 2050.

II. SAF is the most promising option to achieve carbon neutrality in the aviation industry

1. What is SAF?

Sustainable aviation fuel, or SAF, is the main term used in the aviation industry to describe non-fossil derived jet fuel. While it was previously more commonly referred to as "bio-jet fuel", the term SAF is now preferred because it more accurately describes the characteristics of this unconventional fuel. "Biofuel" is usually produced from living resources (plant or animal material). However, current technology allows fuel to be produced from other non-living resources such as municipal solid waste or exhaust gas emitted from industrial processes. Furthermore, in order to be labelled "sustainable", the fuel produced must meet certain environmental criteria, such as life-cycle carbon reduction levels, and a non-competitive relationship with food production. Intergovernmental organisations such as the Roundtable on Sustainable Biomaterials (RSB) have set clear sustainability standards for SAF.

Compared with fossil fuels, SAF can have up to 80% lower carbon emissions across its entire lifecycle. Take SAF made from plants: the carbon dioxide absorbed from the atmosphere by plants during growth is equivalent to the carbon dioxide emitted when the fuel is burned. It is important to note that additional emissions are still generated during fuel production from agricultural equipment, raw material transportation and fuel refining. This means SAF cannot be completely carbon neutral.

2. Characteristics of SAF

SAF is made by mixing conventional kerosene (fossil fuel) and renewable hydrocarbons. These fuels can be certified as "Jet A1" or “Jet A” and can be safely used without any modifications to the aircraft or aviation fuel supply infrastructure. SAF can be safely mixed with general aviation fuel in varying proportions, up to the maximum mixing limit. Fuels with these characteristics are called "drop-in” fuels. This allows SAF to be widely and quickly used in existing equipment and infrastructure as long as it is available in large enough quantities.

3. Technical accessibility of SAF

The production of SAF must be a regulated process to ensure that the quality of the fuel is appropriate for its purpose and is safe to use. Currently, the American Society for Testing Material (ASTM) has approved seven production pathways. Each production pathway has different raw material requirements and production technologies, with its own unique challenges and benefits, for example, the availability of sustainable raw materials, capital investment required for equipment, processing costs, and emissions reduction levels. We have included an overview of the approved production pathways in Appendix 1. More production pathways are currently being developed. Once approved, they can provide manufacturers with more options.

III. Cathay Pacific's path to net zero emissions

Cathay Pacific is one of the industry leaders in taking a proactive approach to manage its climate impact. It took a step further in 2020, committing to achieving net zero carbon emissions by 2050. This is a significant step in its sustainable development journey and coalesces its efforts in fuel efficiency improvement, carbon offsetting and SAF usage. However, Cathay Pacific's experience over the years shows that existing technologies cannot lead to a zero-carbon future. Cathay Pacific's zero-carbon commitment is therefore largely dependent on the large-scale application of SAF.

Technology has been the greatest help for reducing aircraft emissions. From 1998 to 2019, Cathay Pacific improved its fuel efficiency by over 20% with investment in new fuel-efficient aircraft and various operational improvements. Cathay Pacific was also the first Asian airline to introduce a voluntary carbon offset programme to enable customers to offset carbon emissions for their flights. Since its launch in 2007, the Fly Greener platform has offset over 300,000 tons of CO2 emissions. But this is far from sufficient to achieve carbon neutrality.

Cathay Pacific has long identified the importance of SAF to achieve substantial emissions reduction and has made important strategic investments. In 2014, Cathay Pacific became a shareholder and board member of Fulcrum Bioenergy, the first airline to invest in the company. Fulcrum is a SAF development company headquartered in the United States, and a global pioneer in developing and commercialising the conversion of municipal solid waste into SAF. Since 2016, Cathay Pacific has delivered 41 Airbus A350 aircraft from Toulouse to Hong Kong with SAF. To date, the project has used more than 200 tons of SAF. In the process, Cathay Pacific gained valuable experience and knowledge about aircraft performance with the use of SAF.

Cathay Pacific has committed to buying 1.1 million tons of SAF from the Fulcrum plant in the United States over a 10-year period. Starting from 2024, the estimated annual uptake will be equivalent to about 2% of Cathay Pacific’s total fuel demand of 2019 operation levels. However, this is far from what is needed given that over half of Cathay Pacific's flights depart from Hong

Kong SAR, its home base. Cathay Pacific needs to establish a SAF supply chain in the region. While SAF is increasingly available in Europe and the USA, supply in China has not yet taken off. Cathay Pacific believes the development of a SAF supply chain is not only important for the company to meet its 2050 target, but it is of equal importance for the further development of the civil aviation industry in China and for the country to meet its 2060 carbon neutrality goal.

IV. Strategic significance of SAF for China

1. Significance of emissions reduction in China's civil aviation

As the world's second-largest civil aviation market, China's booming civil aviation industry saw its annual revenue increase to RMB 1 trillion in 2019, with 660 million passenger trips and over 7 million tonnes of air cargo. [iv] Civil aviation has made a significant contribution to China's economy. As a key manufacturing and logistics country, air transport plays a vital role in facilitating the flow of goods, direct investments and people, contributing directly to the RMB 9.7 trillion of foreign direct investment and to RMB 15.5 trillion of total exports from China. [v] Looking ahead, aviation will continue to play an important role in China's economic growth. According to forecasts by the International Air Transport Association (IATA), China is expected to become the world's largest civil aviation market by the mid-2020s. [vi] By 2037, the number of passengers could triple, and civil aviation is expected to bring in around RMB 1.8 trillion, providing around 6.7 million jobs in China. [vii]

Given the future growth of China's aviation sector, this poses a challenge in terms of sustainable development, specifically, the likely growth in emissions. China's civil aviation sector emits approximately 100 million tons of CO_2 each year. This level of emissions already ranks second in the world, only after the United States. However, China's per capita aviation emissions are much lower than many countries, about 0.09 tons of CO_2 per person. Corresponding figures for the United States and the United Kingdom are 0.57 and 0.86 respectively. [viii] China sees a huge growth potential in aviation activities and related emissions. If China's per capita emissions increase to the level of the United States, its aviation emissions will reach 600 million tons. With the expected substantial increase in both aviation activities and emissions, China needs to find an effective solution to decarbonise the sector to prove its seriousness in dealing with climate change. From being a big player to the leading player, the path taken by China in terms of its own sustainable development is of great importance to the future of global aviation industry.

2. Opportunities in the global SAF market

As early as 2009, the global aviation industry set a goal to substantially reduce carbon emissions by 2050: net carbon dioxide emissions to be reduced by 50% compared with 2005. [ix] Due to the limited options available, SAF is becoming increasingly important. According to International Energy Agency (IEA) "Beyond 2°C Scenario" [x] , it is estimated that global demand for SAF will reach 150 million tons per year by 2060, which is around 60-70% of total aviation fuel demand.

The above demand forecast shows that the annual potential value of this market will exceed RMB 640 billion. There will be unprecedented demand for SAF in the coming decades, giving China an opportunity to become a leading player in the industry.

3. Energy security and cost effectiveness

Fuel is usually the largest single operating cost of an airline, averaging at 30%. Fluctuations in crude oil prices will directly affect the profitability of airlines. As potential cost drivers are quite different, using SAF can provide airlines with alternative fuel following a different economic trend. The use of SAF will also reduce dependence on fossil fuels, thus achieving risk diversification. Carbon taxes are also expected to increase in the future. Using SAF would reduce the financial burden related to carbon emissions. In addition, SAF is an inevitable development trend. China needs to have foresight in terms of policies to make a long-term investment in this area, cultivate domestic production capacity, improve supply chain construction, and ensure that SAF can play a role in ensuring wider energy independence.

4. Promoting circular economy

Certain production pathways of SAF can also promote a circular economy. Multiple production pathways involve the use of different types of waste materials, whether they are municipal solid wastes, agricultural waste or used cooking oil. Even the use of industrial waste gases could generate circular economic benefits: plastics can be produced from 'recycled carbon' from the waste gases, instead of solely relying on virgin material or physically recycled plastics.

5. Social and economic benefits

SAF can create new job opportunities through a green economy for different parts of the country. In addition to development around cities and industrial districts for SAF processing plants, some rural areas with land that is unviable for food crops may have a suitable climate for the growth of SAF feedstock. Fuel refining infrastructure is often installed close to feedstock sources, thus creating additional jobs and economic activities.

V. Challenges in mass production and application of SAF

1. Current status of global policy environment, production and application

The policy environment can impose a significant influence on the development and application of SAF. As SAF is currently more expensive to produce, favourable policies will be critical to help close the price gap and enable it to compete with fossil fuels until it can reach economies of scale. Across the world, different policy approaches have resulted in very different SAF adoption rates. Currently, the regions with the highest value incentives are the West Coast of the USA and Europe. Additional information of their policy instruments is provided in Appendix 2. With the support of such active policy making, SAF coalitions are usually formed at major aviation hubs. Such coalitions generally involve different industries or organisations, such as airport authorities, airlines, fuel suppliers, regulators or even local governments. The aim of these coalitions is to bring SAF into use by regular scheduled flights from that airport, and to speed up the process to scale up its usage. [xi] A small number of flights are already consistently scheduled using SAF from these airports and show early promise in terms of what could be scalable in future.

Global SAF production is still in its infancy, with volumes well below 1% of total jet fuel demand. Its supply is expected to grow from 2025 onwards and may reach 3 million tons by 2030. However, even so, the total output of SAF is still at quite a low level, accounting for less than 2% of the total demand for aviation fuel. The field is currently dominated by new niche players specialised in SAF production, but some biodiesel producers and traditional fossil fuel companies are also keen to explore development opportunities, with several already active in the market. Most SAF comes from North America and Europe, with a handful of production facilities in Asia, including in Singapore, Japan and China.

2. Current status of production and application of SAF in China

China has mastered key technologies in the production and application of SAF. A test flight with SAF was conducted successfully as early as in 2011. However, the use of SAF is mainly for testing and one-off flights. Currently there is no long-term commitment for the production or usage of SAF.

Test flights have been particularly important to demonstrate the technical capabilities of SAF to the regulators. They have also served as a good showcase to the Chinese aviation industry that SAF is safe and efficient. After the test flight in April 2013, the Civil Aviation Administration of China (CAAC) issued an aircraft airworthiness certificate to Sinopec to prove its conformance with the necessary quality standards. Additional information of test flights running on SAF in China is provided in Appendix 3.

Biofuel has always been a part of China’s strategic plan to reduce dependence on imported energy and as a way to protect the environment. This strategic direction has been reflected in China's past five-year plans. So far, the strategic plan has only focused on biofuels for road transportation, mainly bioethanol. According to the 13th Five-Year Plan, China has set a goal of achieving 15% of non-fossil energy in primary energy consumption by 2020. As a result, China is currently one of the world's largest bioethanol producers, with an annual output of more than 4 billion litres. However, aviation biofuels have not been included in China's current plan. As China did not place significant focus on the demand for SAF, there is currently limited capacity to produce SAF on a commercial scale in China.

VI. Recommendations for the development of SAF in China

There have been over 300,000 flights using SAF in the past ten years, and SAF has firmly established its position as a safe and technically feasible alternative to traditional aviation fuel. The main obstacles preventing the widespread application of SAF are not technical limitations, but economic ones. The main reason that SAF has not been widely applied is “low demand and low supply”. Small output and higher costs make SAF 2-5 times more expensive than traditional jet fuel. It is obvious that SAF cannot compete with fossil fuels unless there is appropriate policy intervention. Supply chain bandwidth is also an issue. Certain types of sustainable raw materials are in short supply, where limited commercial-scale production facilities are mainly used to produce biofuel for road transport, due to policy requirements or government incentives. As a result, development in SAF supply is further lacking.

Since the development of SAF requires cooperation among many parties, a significant amount of investment, and takes many years, all stakeholders need to be engaged and formulate proactive strategies to increase production capacity. As a result, a stable policy environment is extremely important for the establishment of SAF supply chains. With the establishment of the 2060 carbon neutrality target, China has created a favourable environment to support the long-term prosperity and development of the SAF market.

Many studies have confirmed that, in order to achieve the expected results, a basket of policy interventions is more effective than relying on any single policy instrument. This is best illustrated in the way China achieved rapid progress by closely combining policy support and business drive in promoting and developing new energy vehicles. If policies can exert force both in terms of supply and demand, a virtuous circle will be formed. As demand grows, the SAF supply chain will attract more investment, thus further producing a scaled economy, lowering costs and further expanding demand. To ensure the economic efficiency of SAF, incentives in both supply and demand are required in the medium or short term.

To encourage the development of SAF supply chains, national and local governments may consider supporting SAF research and development, and the construction of demonstration plants by means of tax incentives, subsidies, loans, loan guarantees, direct funding, or public-private partnership. Additional policies can be implemented to de-risk investments into SAF production plants. For example, for foreign companies with experience in building and operating SAF facilities in other markets, favourable conditions can be offered to encourage them to bring their technology and experience to China. In addition, we can refer to the successful experience of China's bioethanol market development and also consider setting production targets.

To increase demand, efforts could be exerted on closing cost differences between fossil aviation fuel and SAF. National or local governments may consider introducing incentives for SAF usage. Due to competitive pricing and additional environmental and reputational benefits, airlines will increase the use of SAF and thus further expand market demand. Existing policy incentive frameworks designed for biofuel usage in ground transport can also be revised to include aviation. Increased incentives for aviation over ground transport should be introduced.

Other policies supporting the development of the SAF market include the adoption of globally recognised sustainability standards to facilitate SAF produced in China to tap into the significant global market. Similarly, policymakers could also encourage users to use existing global SAF accounting standards and to participate in their future evolution and revision.

To facilitate the development of SAF in China, we would suggest selecting certain aviation hubs and establishing local SAF coalitions. The coalition should consist of key stakeholders including airport authorities, fuel suppliers, airlines, and local authorities, with the common goal of making SAF usage a reality for flights departing from that airport on a regular basis. Experience from these pilot sites can then be applied to airports around the country.

We would further suggest selecting the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) as one such pilot site. The HKSAR Government and Cathay Pacific share the same ambitious goal of becoming carbon neutral by 2050. The Hong Kong Airport Authority has also been taking a leading position in the international community in terms of climate change mitigation efforts. Leveraging industrial development, capital flow, technologies and talents in the Greater Bay Area and with government guidance and policy support, we believe Cathay Pacific's experience in SAF could help GBA become an important forerunner in SAF development in China.

Conclusion

China is well positioned to take a leading role in the global race to net zero emissions to reduce the billions of tons of greenhouse gases added to the atmosphere every year from human activity. Achieving this level of reduction will require a fundamental transformation in every aspect of our lives from energy generation and storage, food production, transportation, manufacturing, the built environment and more.

An enabling policy and regulatory environment for piloting and adopting innovate technologies will be critical for facilitating the transition to net zero emissions. Swire Group companies are testing and adopting a variety of cutting-edge technologies and strategies to improve efficiency and energy savings. Since 2011, Swire Properties has partnered with Tsinghua University through the Joint Research Centre for Building Energy Efficiency and Sustainability to develop and test methods to improve its environmental performance. We support the transition of renewable energy through onsite generation and power purchase agreements. So far, Swire Properties' development in Chengdu and Swire Coca-Cola's Yunnan manufacturing site were powered by 100% renewable electricity.

The common experience of Swire's various business segments, including Cathay Pacific, Swire Coca-Cola and Swire Properties, all show that the guidance and support from government policies are crucial for the business community to achieve its carbon reduction targets. The government can consider encouraging the use of renewable energy, promoting techniques such as smart grids, energy storage battery systems, as well as carbon capture and storage technology to provide more technical tools and institutional networks for carbon reduction projects, expand technological innovation and penetration, and create new financing mechanisms, especially those designed to support net-zero strategies and action plans. Having operated in China for over one and a half centuries, Swire is fully committed to supporting China's path to carbon peaking and carbon neutrality, and to play its part in ensuring that China realises its overall vision for sustainability.

Appendix 1 Seven production pathways for SAF approved by ASTM

Pathway	Raw material (example)	Approved date	Mixing limit
Fischer-tropsch synthetic paraffinic kerosene (FT-SPK)	Biomass energy (forestry residue, weeds and municipal solid waste)	2009	Up to 50%
Hydrotreating esters and fatty acids (HEFA)	Oil-based biomass energy, such as camelina oil, carinata oil, and waste oil	2011	Up to 50%
Hydrotreating fermented sugar-synthesis isoparaffin (HFS-SIP)	Sugar cane, sucrose	2014	Up to 10%
FT-SPK with aromatics (FT-SPK/A)	Biomass energy (forestry residue, weeds and municipal solid waste)	2015	Up to 50%
Alcohol to jet-synthetic paraffinic kerosene (ATJ-SPK)	Agricultural waste (hay, weeds, forestry residue and straw), corn and sugar cane Waste gas emitted during industrial production	2016	Up to 50%
Catalytic hydropyrolysis jet fuel (CHJ)	Soybean oil, jatropha oil, camellia oil, camelina oil, and carinata oil	2020	Up to 50%
Hydrotreating hydrocarbons (HH-SPK)	Seaweed oil	2020	Up to 10%

Appendix 2: Examples of policies supporting SAF

US Renewable Fuel Standard (RFS)

- RFS sets mandatory targets for the use of bio-fuels for refineries and suppliers - 36 billion gallons by 2022. There is also a trading market established for the production of such renewable fuels so that producers can profit from it.

US California Low Carbon Fuel Standard (LCFS)

- LCFS aims to reduce the carbon emission intensity of transportation by 20% by 2030. LCFS supervises fuel suppliers and provides them with carbon value based on the type of fuel they produce. It can be seen as a form of "subsidy for carbon reduction".

UK Renewable Transport Fuel Obligation Act (RTFO)

- RTFO aims to supply 450k litres of SAF each year and aims to meet 12.4% of total fuel needs by 2032. There is a preference for waste-based fuels with specific usage target and a double incentive offered.

EU Renewable Energy Directive (RED)

- RED commits to providing 14% of renewable fuels for the transport sector, including the aviation industry, by 2030. Extra credit is offered for SAF, and certain types of waste derived fuels can also get 1.2 times credit.

Netherlands Transport Energy Obligation Act (HBE Credit)

- HBE mandates companies to increase the share of renewable energy in their fuel supply. The airline industry can choose to take part to benefit from the incentive credits on offer.

Appendix 3 Information of flight tests operated using SAF in China

Date	Airline	Fuel description	Fuel source	Flight description
Oct. 28, 2011	Air China	Fuel refined from 50% jatropha oil	PetroChina	Test flight from Beijing
Apr. 24, 2013	China Eastern Airlines	Fuel refined from palm oil and waste cooking oil	Sinopec	1.5-hour test flight at Shanghai Hongqiao Airport
Mar. 21, 2015	Hainan Airlines	50% SAF refined from waste cooking oil	China National Aviation Fuel Corporation	The first domestic passenger flight Boeing 737-800 from Shanghai to Beijing
May 28, 2016	Cathay Pacific Airways	10% SAF refined from sugar cane	Total SE / Amyris, Inc. (AMRS)	Delivery flight from Toulouse to Hong Kong using SAF
Nov. 22, 2017	Hainan Airlines	15% SAF refined from waste cooking oil	Sinopec	Boeing 787 flight from Beijing to Chicago - the first cross-sea flight using SAF
Feb. 28, 2019	China Eastern Airlines	10% SAF refined from sugarcane	Total SE	Delivery flight of A320neo from Toulouse to Guangzhou

References

[i] https://unglobalcompact.org/take-action/events/climate-action-summit-2019/business-ambition

[ii] https://www.icao.int/sustainability/pages/facts-figures_worldeconomydata.aspx

[iii] As COVID-19 has had a significant impact on the aviation industry, the emission data for 2019 will be used in the pilot phase of CORSIA.

[iv] http://www.xinhuanet.com/english/2020-01/14/c_138704443.htm

[v] https://www.iata.org/en/iata-repository/publications/economic-reports/china--value-of-aviation/

[vi] http://www.xinhuanet.com/english/2020-01/14/c_138704443.htm

[vii] https://www.iata.org/en/iata-repository/publications/economic-reports/china--value-of-aviation/

[viii] https://www.carbonbrief.org/emissions-from-chinese-aviation-could-quadruple-by-2050

[ix] https://www.iata.org/en/programs/environment/climate-change/

[x] https://www.iea.org/reports/world-energy-model#scenarios-in-weo-2020

[xi] About SAF coalitions around the world, Schiphol Airport (AMS) in Amsterdam, Netherlands, is a successful example, with KLM Royal Dutch Airlines being one of its major partners. Many airports on the West Coast of the USA have made similar moves with their fuel suppliers and airlines, including San Francisco International Airport (SFO), Los Angeles International Airport (LAX) and Seattle-Tacoma International Airport (SEA).